Timing techniques for two-dimensionally segmented HP-Ge detectors

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Research and development of the gamma ray energy tracking array (GRETA) has shed light on many new and old topics in gamma ray spectroscopy with HP-Ge detectors. One such topic is obtaining the time at which a gamma ray interacts in the detector crystal. Accurately measuring the time of an interaction is a crucial element in the tracking of gamma rays. Since the signals from the segmented GRETA detectors will be stored digitally, it is important to insure that algorithms used to extract the time of interaction provide time resolutions comparable or better than that of existing analog techniques.

In order to study the digital timing algorithms, a series of coincidence measurements were made using the GRETA prototype detector as well as an unsegmented coaxial germanium detector. Using a barium fluoride detector as the second detector in the coincidence, an analog time spectrum was obtained from both of the germanium detectors using ^{60}Co and ^{22}Na sources. The analog setup consisted of a timing filter amplifier, constant fraction discriminator, time to amplitude converter and a multichannel analyzer. To test a digital timing algorithm, signals from both of the detectors where recorded using a 100 MHz 12 bit waveform digitizer. In this setup the barium fluoride detector was used as the trigger to the digitizer. The recorded signals where then analyzed using a timing algorithm we developed to perform constant fraction timing.

The measured analog and digital time resolution for the unsegmented detector can be seen in Figure 1. Use of the digital timing algorithm shows improvement over the standard analog timing method. Figure 1 also shows the results obtained with the segmented GRETA detector for each of the segment layers tested (1 being the front segment). Again the digital timing algorithm showed improvement over the analog method. It is interesting to note that the measured time resolution reflects the variation in raise time of the signals in each of the given layers. The second layer having the largest range in raise time has the worst time resolution. Since good position sensitivity (another crucial element needed in GRETA) is obtained with large signal dynamic range, there is a trade off between the two.

The digital timing algorithm was found to perform slightly better than the standard analog method. We believe that further work on the algorithm, such as deconvolution of the response from the measured signals, will additionally enhance the time resolution.

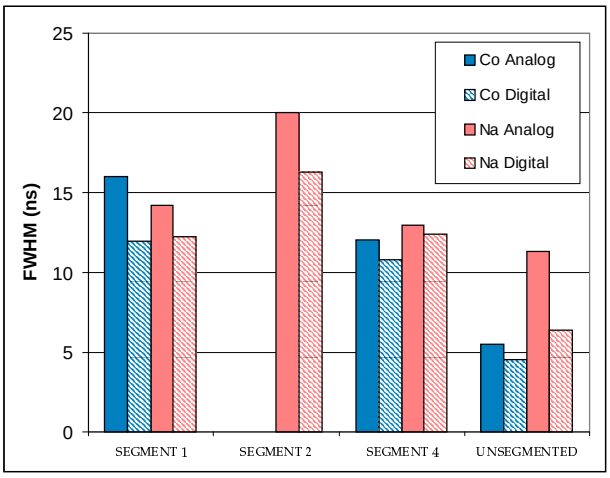

Fig. 1. Time resolution (FWHM) for the analog (solid) and the digital (crosshatched) methods for both the segmented GRETA detector and the unsegmented Ge detector.